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(54) **ANTI-COUNTERFEITING SYSTEM AND METHOD**

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(51) **Int. Cl.**
B42D 15/00 (2006.01)

(52) **U.S. Cl.** **283/117**

(58) **Field of Classification Search** 235/379, 235/494; 283/117, 901, 902; 219/687, 761, 219/759, 634, 635, 448, 460.1, 121.36, 121.59, 219/121.52

See application file for complete search history.

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(57) **ABSTRACT**

Disclosed is an anti-counterfeiting system. In a particular embodiment, the anti-counterfeiting system has a first structure having a plurality of three-dimensional nanostructures, each having a height dimension less than a wavelength of visible light. In addition, there is a second structure having a second plurality of three-dimensional nanostructures, each having a height dimension less than a wavelength of visible light. The first and second structures are configured to couple together. An alignment mechanism is operable to align the first structure to the second structure and establish proximate contact between the first and second pluralities of nanostructures. With respect to the first and second structures, each encodes part of an authentication key. The authentication key includes pre-determined elements and interaction modalities. The resolution of the structures makes them copy-resistant. An associated method of use is also provided.

40 Claims, 6 Drawing Sheets

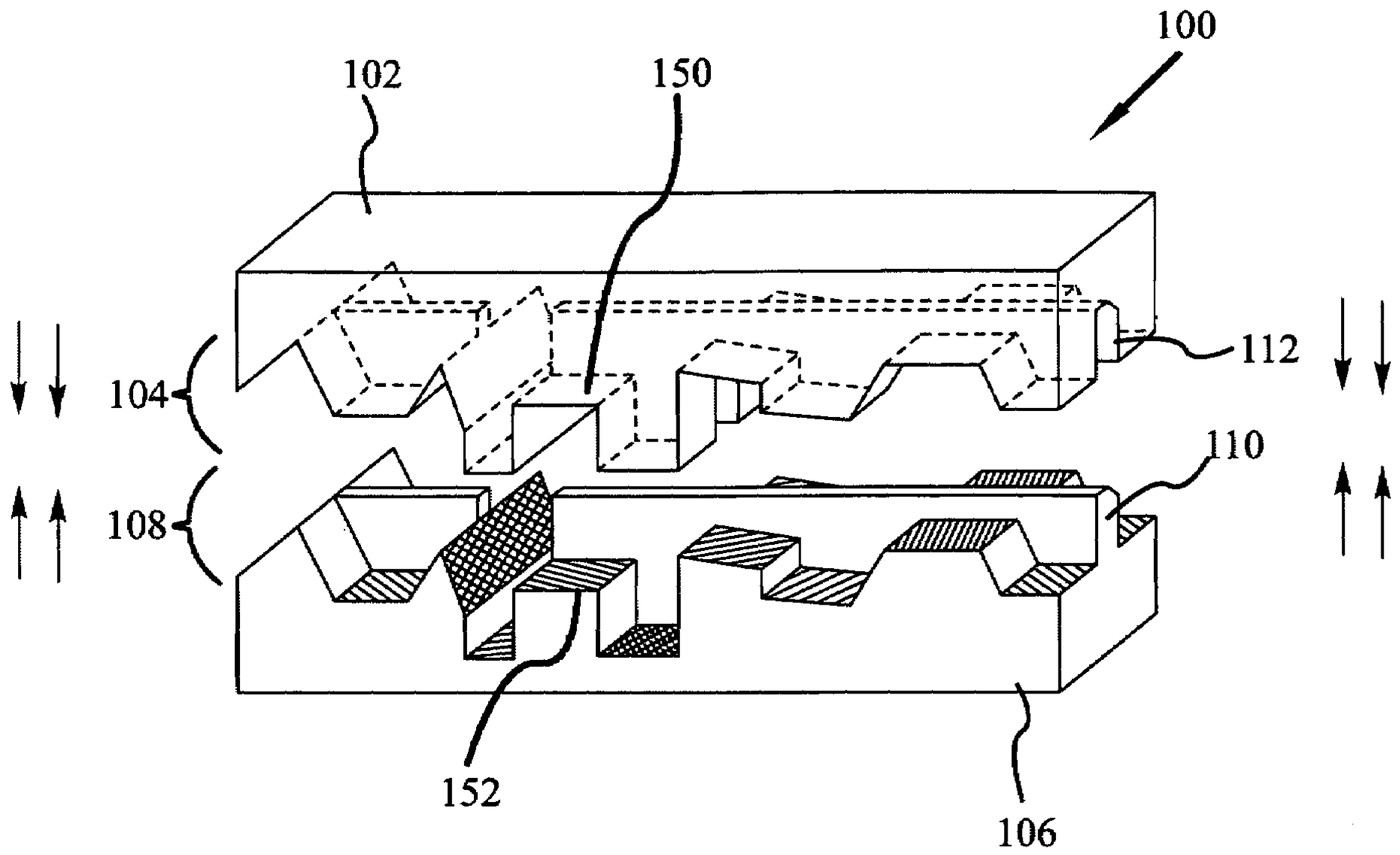


FIG. 1

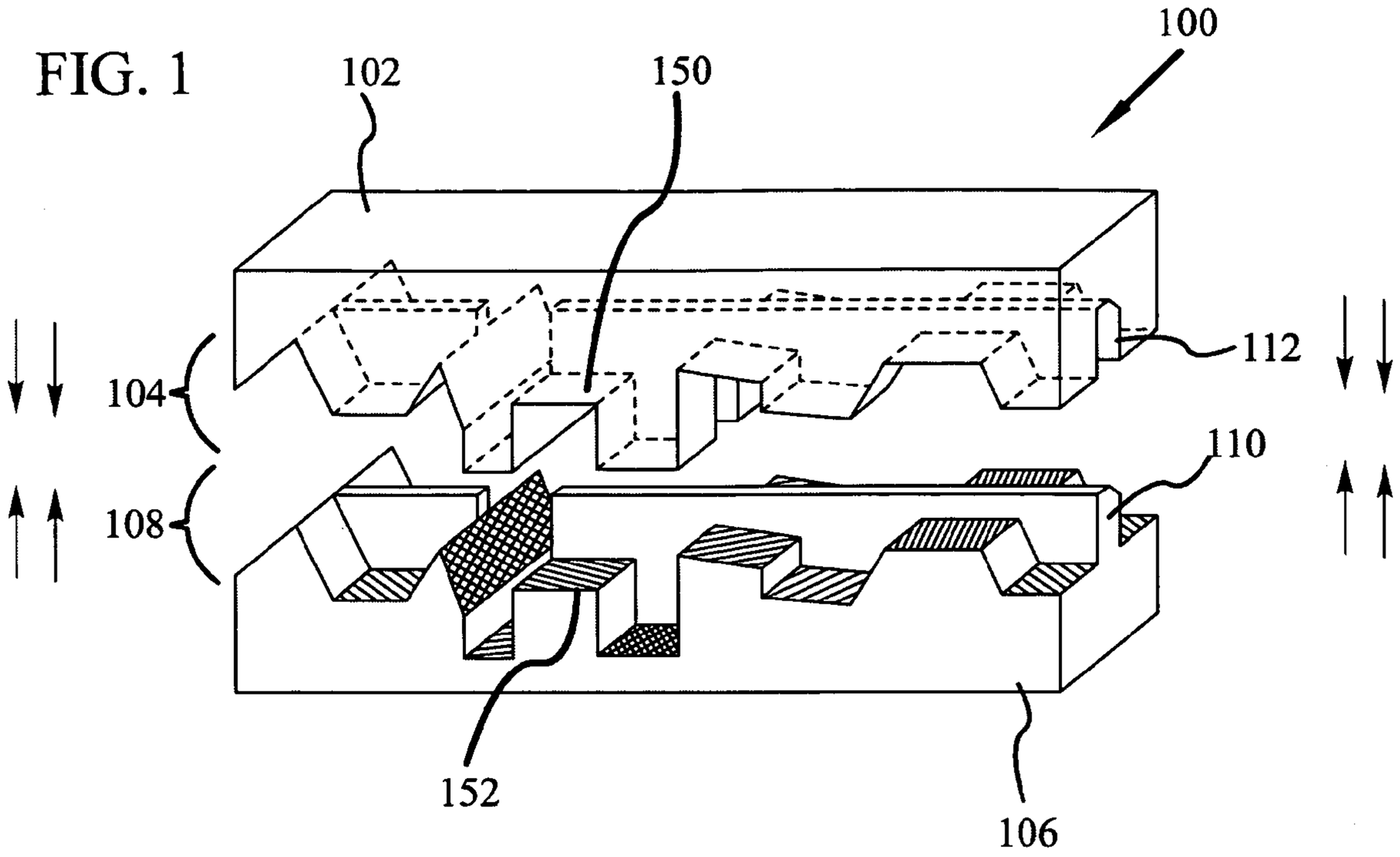

100
102
150
112
104
110
108
152
106

FIG. 2

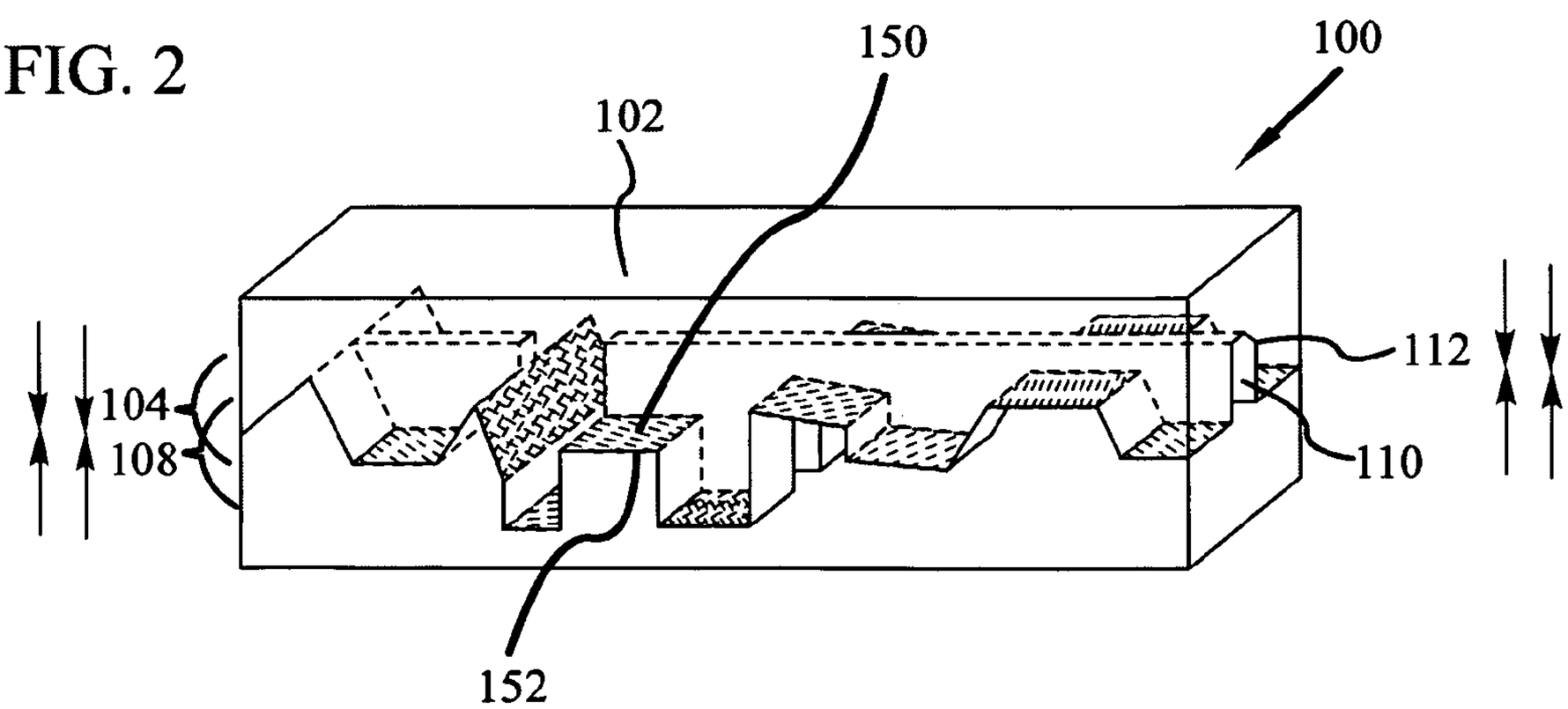

150
100
102
112
104
108
110
152

FIG. 3

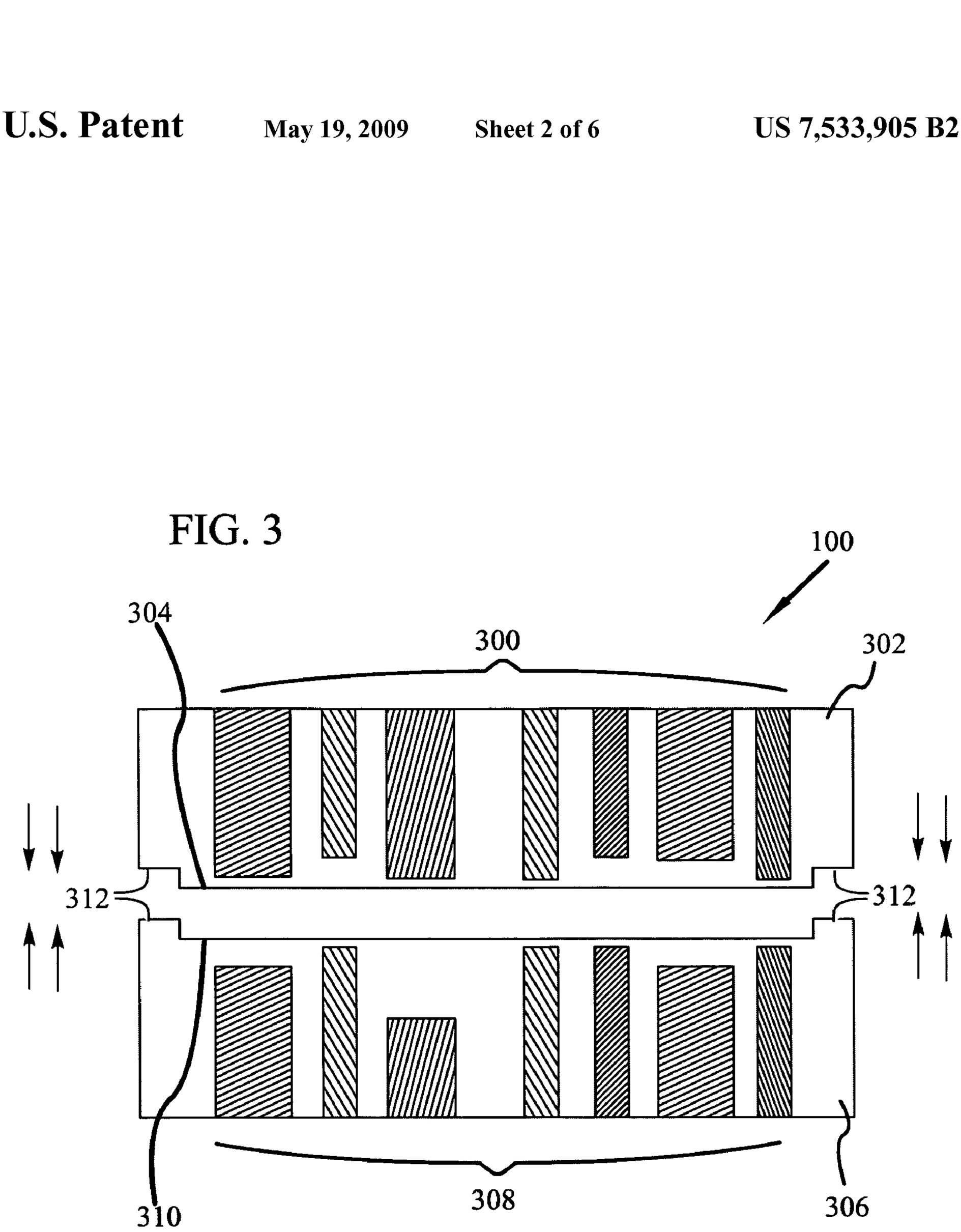


FIG. 4

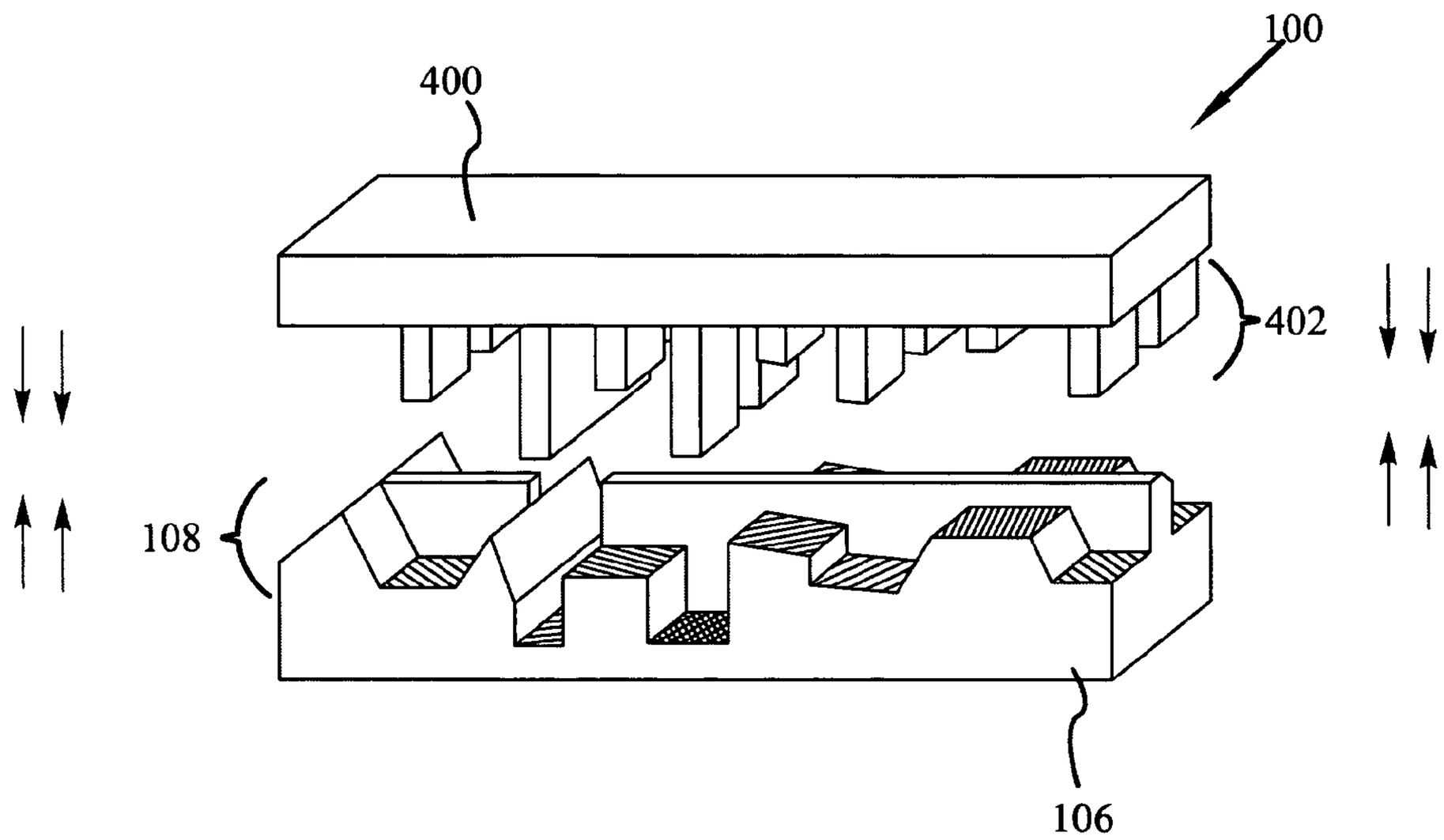


FIG. 5

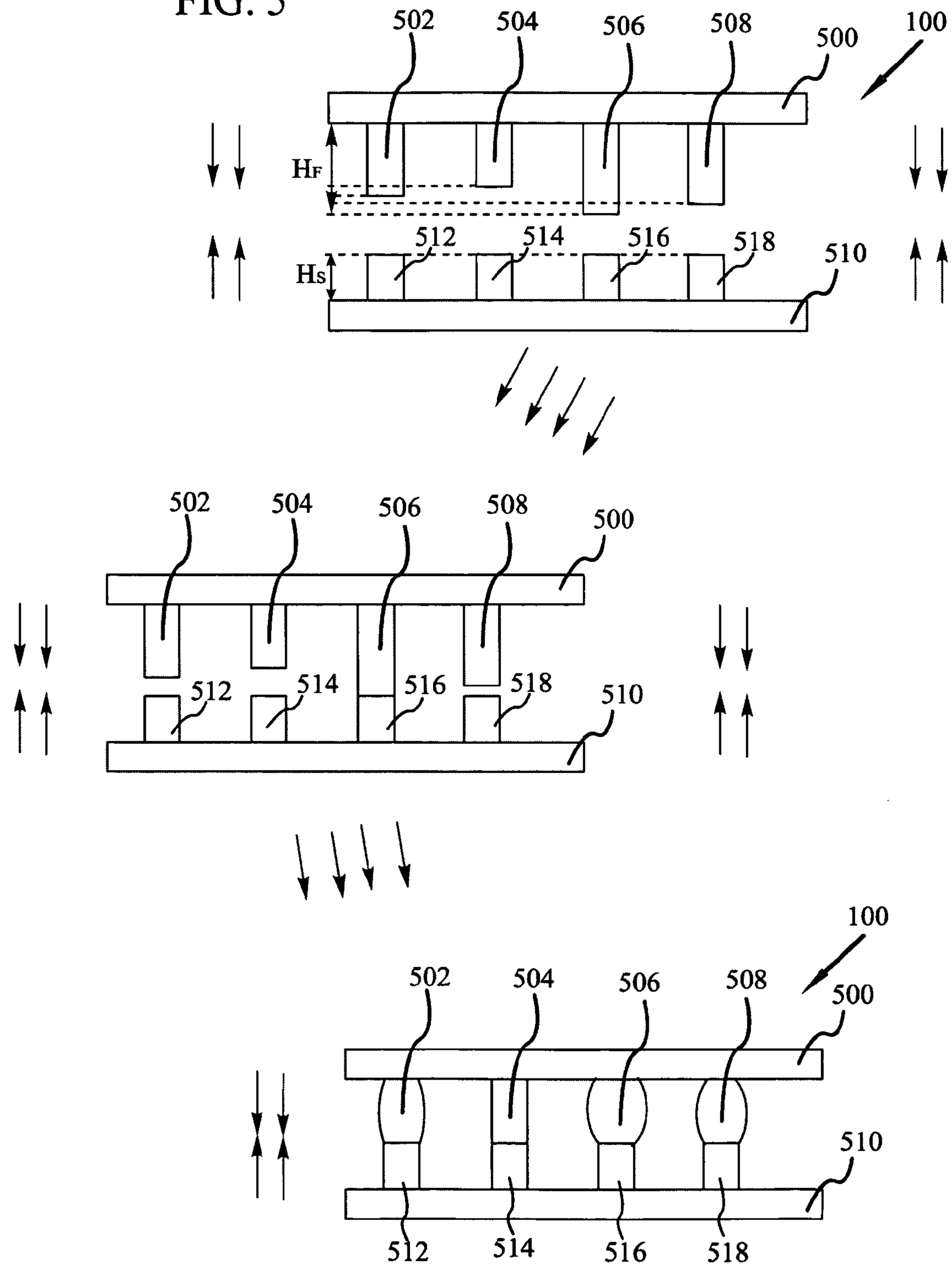

502
504
506
508
500
100
HF
512
514
516
518
510
Hs
502
504
506
508
500
512
514
516
518
510
100
502
504
506
508
500
510
512
514
516
518

FIG. 6

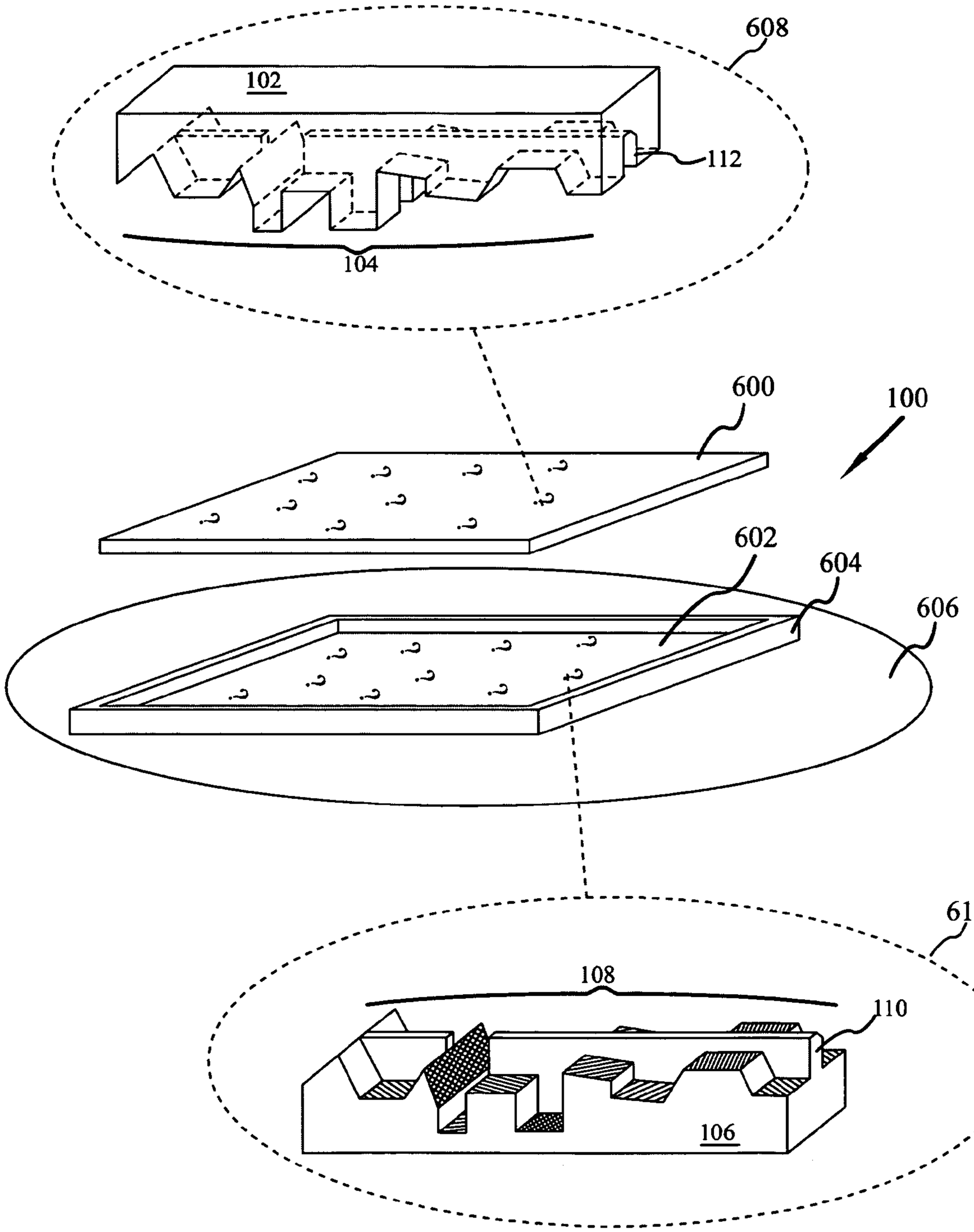
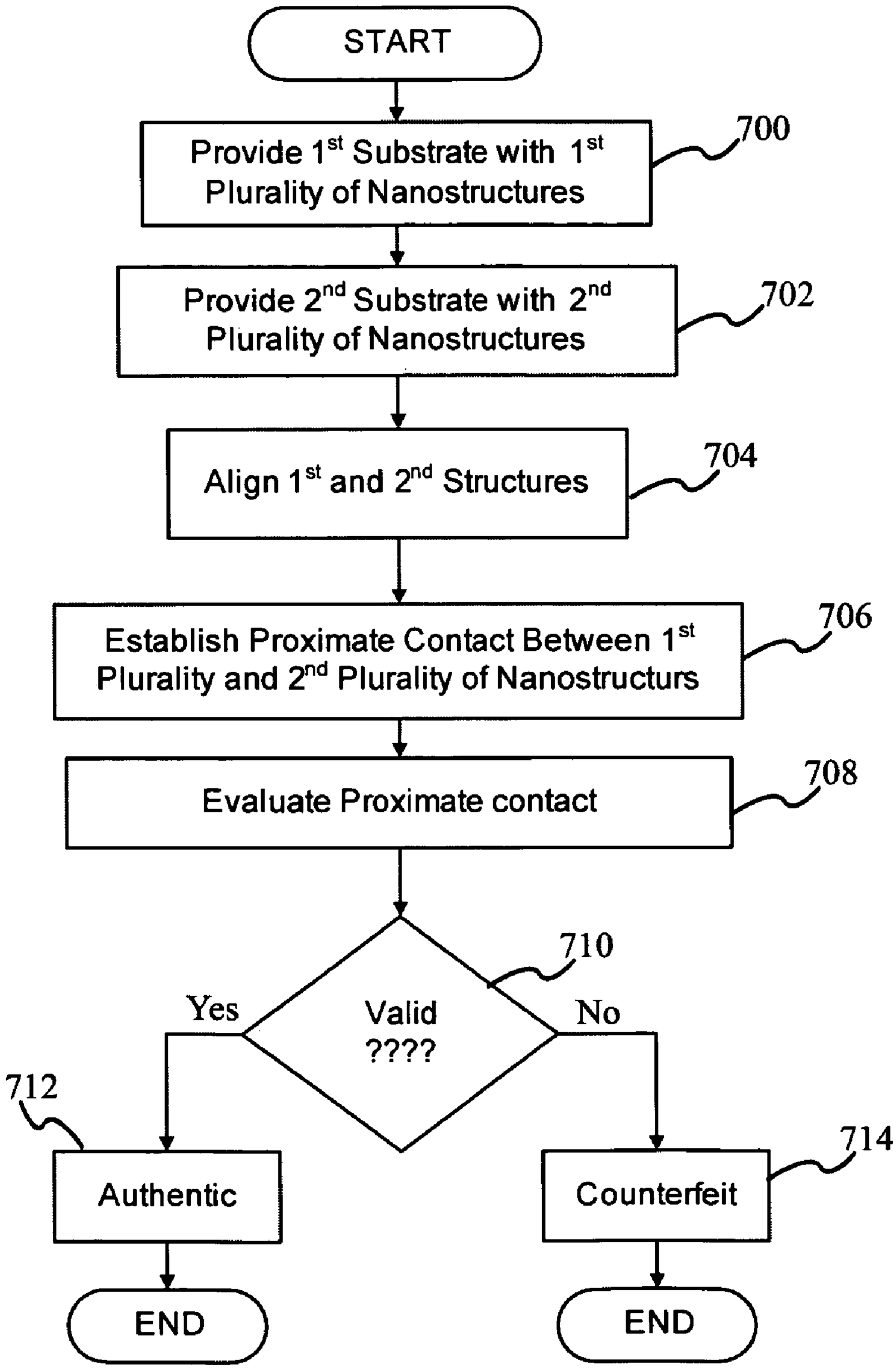


FIG. 7


START
Provide 1st Substrate with 1st Plurality of Nanostructures
700
Provide 2nd Substrate with 2nd Plurality of Nanostructures
702
Align 1st and 2nd Structures
704
Establish Proximate Contact Between 1st Plurality and 2nd Plurality of Nanostructurs
706
Evaluate Proximate contact
708
Valid ????
710
Yes
No
Authentic
712
Counterfeit
714
END
END

ANTI-COUNTERFEITING SYSTEM AND METHOD

FIELD OF THE INVENTION

This invention relates generally to security and anti-counterfeiting devices.

BACKGROUND OF THE INVENTION

Recently, there has been a growing need to develop systems and methods to combat counterfeit products. In the case of aircraft parts, drugs and food products such as baby formula, the consequences of counterfeit products can have devastating effects on health and equipment. Counterfeit national currency has also become a growing concern.

As recognizable as some brand names are with respect to general consumable products, unscrupulous parties commonly market counterfeit products to unknowing customers. There is lost revenue to the real Trademark/Trade Name holder when these counterfeit products are bought and sold. In addition, in the case of ink jet products or toner products for example, these counterfeit products often damage the systems into which they are placed. As the counterfeit was not realized, the real Trademark/Trade Name holder is often the party approached for repair or replacement, even though they were not the source of the counterfeit product.

Manufacturers of products have begun to incorporate systems and methods in an effort to thwart such counterfeit activity. Generally speaking, these systems and methods can be categorized into four basic groups:

1) Printed Materials such as, for example, hologram, fine patters of printed ink, watermarks and the like;
2) Printing Related Items such as, for example, inks that change color with the viewing angle, controlled sources of paper (e.g., currency paper) and the like;
3) Computer Systems such as special chips that are active or passive and wireless circuits; and
4) Control Numbers such as, for example, serial numbers that have some relation to the product or hash codes that are uniquely generated.

Anti-counterfeit measures generally attempt to address two elements: difficulty of forgery, in other words, a system or method that is difficult to forge; and ease of use—a system or method that is easily to use and/or recognize and verify. Ease of use is quite important as an effective method or system will typically be used by everyday people in everyday commerce with a wide range of skills in a variety of settings.

In many cases, the anti-counterfeit measure is meant to be optically detected, for example in the case of a dollar bill. Although the bill is printed on special paper with special ink and high resolution elements, optical dollar bill scanners often query only the image provided on the bill. A high-resolution photograph of a dollar bill may therefore be as acceptable to some optical scanning systems as a real dollar itself.

That a picture of a dollar bill may confuse an optical scanner but appear obviously different from a real dollar bill to a human observer highlights yet another consideration in anti-counterfeit technology. Namely, that detection by both persons and non-persons is frequently desired, but may be difficult to achieve.

When an anti-counterfeiting system and method are employed, the elements of the system are often analyzed and meticulously duplicated, such as in the case of holographic stickers or emblems. Originally, holographic emblems and stickers seemed ideal devices to indicate authenticity. However, as sophisticated technologies have advanced in micro-scale fabrication techniques, the ability to render counterfeit holograms has also advanced.

As a retort, attempts have been made to develop anti-counterfeit devices that are destroyed if removed from an authentic source, as is typically required for counterfeit duplication or use. Although somewhat effective, counterfeit duplication and use remains a concern.

The micro-miniaturization of electrical systems and electro-mechanical systems has advanced significantly. There is typically a high cost associated with micro-minaturization fabrication processes such as photolithography. Mass production, such as with roll-to-roll technology, can be difficult to achieve. Whereas a transistor or memory element at the heart of a component may justify the expense for a lithographic fabrication process, an anti-counterfeiting system or method affixed to an article of manufacture generally has not justified such expense

Hence, there is a need for an anti-counterfeiting system and/or method that significantly thwarts duplication and counterfeiting while also being cost effective to manufacture, provide and utilize.

SUMMARY

This invention provides an anti-counterfeiting system.

In particular, and by way of example only, according to an embodiment, provided is an anti-counterfeiting system, including: a first structure having a first plurality of three-dimensional nanostructures each having a height dimension less than a wavelength of visible light; a second structure having a second plurality of three-dimensional nanostructures each having a height dimension less than a wavelength of visible light, the second plurality configured to couple with the first plurality; and an alignment mechanism, operable to align the first structure to the second structure and establish proximate contact between the first and second pluralities of three-dimensional nanostructures; wherein the first plurality of three-dimensional nanostructures encodes a first part of an authentication key, and wherein the second plurality of nanostructures encodes a second part of the authentication key, the authentication key including pre-determined elements and interaction modalities

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** a partial perspective view of primary components of an anti-counterfeiting system according to an embodiment;

FIG. **2** is a partial perspective view of the anti-counterfeiting system of FIG. **1** showing the components in proximate contact;

FIG. **3** is a an alterative embodiment of the primary components of an anti-counterfeiting system;

FIG. **4** is a progressive illustration of the compliant primary components providing a temporal pattern of proximate contact;

FIG. **5** illustrates a temporal pattern of proximate contact employed in at least one embodiment of an anti-counterfeiting system.

FIG. **6** is a partial perspective view in human scale of the primary components of the anti-counterfeiting system shown in FIG. **1**; and

FIG. **7** is a high level flow diagram illustrating an anti-counterfeiting method according to an embodiment.

DETAILED DESCRIPTION

Before proceeding with the detailed description, it is to be appreciated that the present teaching is by way of example, not by limitation. Thus, although the instrumentalities described herein are for the convenience of explanation shown and described with respect to exemplary embodiments, it will be appreciated that the principles herein may be equally applied in other types of anti-counterfeit devices. It will be appreciated that the drawings are not necessarily drawn to scale and may be expanded in certain aspects for ease of discussion.

Referring now to the drawings, and more specifically to FIG. **1**, there is shown a portion of an anti-counterfeiting system (hereinafter "ACS") **100** in accordance with at least one embodiment. Moreover, as shown ACS **100** includes a first structure **102** having a first plurality of 3D nanostructures **104** and a second structure **106** having a second plurality of 3D nanostructures **108**.

As illustrated, the second plurality of nanostructures **108** is configured to couple with the first plurality of nanostructures **104**. As second structure **106** is exposed to the viewer, it may be further appreciated that each hatching pattern represents electrically distinct contacts. In the exemplary embodiment illustrated, a central ridge **110** on the second structure **106** aligns to a groove **112** in the first structure **102**. Collectively, ridge **110** and groove **112** provide an alignment mechanism.

When the first and second structures **102**, **106** are brought together and aligned, proximate contact between the first and second pluralities of nanostructures **104**, **108** is established. Moreover, the configuration to couple first and second pluralities of nanostructures **104**, **108** may be one of several forms, such as for example: physical contact, electrical contact, capacitive proximity, magnetic interaction, photoelectric contact, mechanical contact and/or combinations thereof.

Specifically, in at least one embodiment the proximate contact when coupled is physical contact between at least one nanostructure of the first plurality **104** and at least one nanostructure of the second plurality **108**. In an alternative embodiment, the proximate contact when coupled is electrical contact between at least one nanostructure of the first plurality **104** and at least one nanostructure of the second plurality **108**. In yet another alternative embodiment, the proximate contact when coupled is magnetic interaction, such as the magnetic alignment of one nanostructure of the first plurality **104**, which may influence and/or interact with the magnetic alignment of one nanostructure of the second plurality **108**.

In still another alternative embodiment, the proximate contact when coupled is mechanical, such as the deformation of at least one nanostructure by another, e.g., a cantilever nanostructure of the second plurality **108** deformed by a nanostructure of the first plurality **104**. In an alternative embodiment, the proximate contact when coupled is photoelectric. Specifically, the materials forming the nanostructures of the first and second pluralities **104**, **108** affect light passing through so as to generate a pre-determined response in a photoelectric element in the second structure **106**.

In yet another alternative embodiment, the proximate contact when coupled is capacitive proximity between at least one nanostructure of the first plurality **104** and at least one nanostructure of the second plurality **108**. In at least one embodiment, capacitive contact is the preferred form of proximate contact as the avoidance of direct contact reduces susceptibility to debris, stress and wear.

Further, in at least one alternative embodiment, the proximate contact when coupled may be a combination selected from physical contact, electrical contact and capacitive proximity between at least one nanostructure of the first plurality **104** and at least one nanostructure of the second plurality **108**. In addition, so as to enhance the anti-counterfeit properties of the system, generally a plurality of nanostructures in the first and second pluralities of nanostructures **104**, **108** achieve proximate contact. Moreover, when the first and second structures **102**, **106** are aligned, the first and second pluralities of nanostructures **104**, **108** provide unique geometric shapes and gaps. These shapes and gaps establish pathways with predetermined magnetic, photoelectric, conductive or capacitative values, and combinations thereof.

As shown in FIG. **2**, physical and/or electrical proximate contact has been established between the illustrated first and second pluralities of nanostructures **104**, **108**. With respect to both FIGS. **1** and **2**, each nanostructure may be an electrically distinct contact, an electrical device (e.g., a TFT, tunnel junction memory, etc.), or a portion of an electrical device.

For example, in at least one embodiment, a nanostructure on first structure **102** provides the gate electrode for a nanostructure on second structure **106**, providing a source, drain and channel. In another embodiment, nanostructures on first structure **102** provide a capacitor and corresponding nanostructures on second structure **106** provide a inductor. Proximate contact between the inductor and capacitor causes the whole to form a tank circuit with desired oscillation frequencies.

Moreover, in at least one embodiment, the first plurality of three-dimensional nanostructures **104** encodes a first part of an authentication key and the second plurality of nanostructures encodes a second part of an authentication key.

When coupled, the first and second pluralities of nanostructures **104**, **108** provide a complete authentication key. Specifically, in at least one embodiment, when coupled to provide proximate contact, the first and second pluralities of nanostructures **104**, **108** interact using pre-determined elements and interaction modalities. More specifically, the elements include pre-determined physical geometry. The modalities include, but are not limited to, electrical conduction, magnetic interaction, photoelectric interaction, mechanical operation and/or combinations thereof. If the physical geometry does not align, the other involved elements and/or modalities will not function.

For example, when formed of specifically different materials, the electrically conductive properties of the nanostructures may be selectively chosen so as to provide a unique electrical signal. By combining physical geometry with electrical conduction, the level of complexity of the device may be advantageously elevated.

In at least one embodiment, the coupled nanostructures provide a tunnel junction memory cell. More specifically, nanostructure **150** on first structure **102** may provides a ferromagnetic layer with a known orientation and a tunnel junction layer as a cap layer on the distal end of nanostructure **150**. Mating nanostructure **152** on second structure **106** provides a ferromagnetic layer with a known orientation. When coupled, the known orientations (e.g., parallel or anti-parallel) will impose a detectable level of resistance upon a current tunneling through the coupled structure.

This detected resistance may be converted to a binary value such as a data "1" or a data "0". In an embodiment wherein a plurality of coupled nanostructures provide magnetic tunnel junctions or other resistive tunnel junctions, a binary code

may be pre-encoded as an element of the anti-counterfeiting system. Such a binary code may be a digital fingerprint.

As used herein, the term "digital fingerprint" is applied to a unique cryptographic hash such as, for example, an MD5 hash. A digital fingerprint may also be referred to as a message digest. With a cryptographic hash, the security properties ensure that the fingerprint is random to prospective attackers and does not leak or hint any information about the message itself such as, for example, an authorization code, serial number, activation key or the like. In addition, no other different message will provide the same digital fingerprint.

Any change to the message, even a single bit change, will result in a dramatically different hash, and any change to the hash, even a single bit change, will result in a dramatically different message. The following example demonstrates this characteristic when performing an MD5 hash. In the second instance the letter "d" is changed to a "c".

MD5 (Message Digest Algorithm 5) Example

MD5("The quick brown fox jumps over the lazy dog")
=9e107d9d372bb6826bd81d3542a419d6

MD5("The quick brown fox jumps over the lazy cog")
=1055d3e698d289f2af8663725127bd4b

A cryptographic hash is considered secure if it is not computationally feasible to determine the content of the message from the hash, and/or to find instances where two or more different messages have the same hash value. In at least one embodiment, such a cryptographic hash is encoded in ACS **100** as the electrical conduction properties established by proximate alignment between the first and second pluralities of nanostructures **104**, **108**.

In at least one embodiment, either the first structure **102** or the second structure **106** is connected to a power source sufficient to enable the electrical components of ACS **100**. In addition, in at least one embodiment, a suitable controller may be electrically coupled to the first structure **102** as well. A suitable controller may be comprised of analog circuitry, a digital processor, a CPU programmed with control logic, a device driver and combinations thereof. Under appropriate circumstances, the controller, or portions of the controller, may be integrated with the first structure **102**. It is of course understood and appreciated that a power source and/or controller may be coupled to the second structure **106** in addition to, or in place of, such connections to the first structure **102**.

As indicated by the choice of terms, the first and second pluralities of nanostructures **104**, **108** are exceedingly small. More specifically, the nanostructures each have height and width dimensions of between about 0.5 to 5 μm. Moreover, in at least one embodiment, each nanostructure member of the first and second pluralities of nanostructures **104**, **108** has a height dimension less than a wavelength of visible light. As such, the first and second pluralities of nanostructures **104**, **108** advantageously can not be photographed or optically detected. Such fine resolution of the first and second pluralities of nanostructures **104**, **108** prohibits reproduction as counterfeiters likely do not have the highly sophisticated fabrication technology necessary to render first and second pluralities of nanostructures **104**, **108**. In addition, such fine resolution renders the first and second pluralities of nanostructures **104**, **108** difficult to detect visually, or to identify such structures as necessary security structures. Enabled by the small size, the creation of hidden and not easily detectable security structures greatly complicates counterfeiting.

In addition, attempts to use either the first structure **102** or the second structure **106** as a template for a counterfeit component is thwarted by the small scale of the structures and their nearly certain destruction. Stated more simply, the structures are small enough to function, but too small to survive dissection. Specifically, the first and second pluralities of nanostructures **104**, **108** are copy-resistant.

Moreover, any attempt to separate the first or second pluralities of nanostructures **104**, **108** from either the first or second structure **102**, **106** will result in the destruction of the nanostructures. In other words, the components of ACS **100** are operationally inseparable, for attempts to separate the nanostructures from their respective first or second structures will render the ACS **100** inoperable. Such inoperability and copy-resistance may be advantageous in thwarting attempts to counterfeit ACS **100**.

FIG. **3** illustrates an alternative ACS **100** embodiment wherein the first plurality of nanostructures **300** are hidden within first structure **302**, e.g., below surface **304**. Likewise, the second plurality of nanostructures **308** are hidden within second structure **306**, e.g., below surface **310**. In at least one embodiment, pluralities of nanostructures **300** and **308** are understood to be substantially identical to nanostructures **104** and **108** described above

In at least one embodiment, where surfaces **304** and **310** are solid, when the first and second structures **302**, **306** are brought together and aligned by alignment guides **312**, the first and second pluralities of nanostructures **300**, **308** couple by capacitive proximity. In such an embodiment, not only does the nano-scale size of the first and second pluralities of nanostructures **300**, **308** render them hidden from visual observation, but they are also concealed by the material forming surfaces **304** and **310**.

In at least one alternative embodiment, surfaces **304** and **310** provide a plurality of apertures to permit the first and second pluralities of nanostructures **300**, **308** to move and establish proximate contact in accordance with at least one modality introduced above when the first and second structures **302**, **306** are brought together and aligned by alignment guides **312**. In such an embodiment, the nano-scale size of the first and second pluralities of nanostructures **300**, **308** again renders them hidden from visual observation. In addition, when the first and second structures **302**, **306** are not brought together the first and second pluralities of nanostructures **300**, **308** are hidden below the surfaces **304** and **310**.

FIG. **4** illustrates an alternative ACS **100** embodiment wherein the first structure **400** provides a first plurality of three-dimensional nanostructures **402** that are not mirror copies of the second plurality of three dimensional nanostructures **108** provided by second structure **106**. The first plurality of nanostructures **402** and second plurality of nanostructure **108** are still configured to couple when the first and second structures **400**, **106** are brought together and aligned. As in the ACS **100** embedment depicted in FIGS. **1~3**, if appropriate proximate contact in the form of electrical, physical and/or capacitive proximity is established, verification of authenticity is achieved.

In at least one embodiment, at least a portion of the first and second pluralities of nanostructures **104**, **108**, **402** are formed from compliant materials. Specifically, the material may be compressed when the first and second structures are brought together and aligned. Most plastics and polymers are compliant. A very compliant material appropriate for use in at least one embodiment is Polydimethylsiloxane elastomer, more commonly referred to simply as "PDMS".

FIG. **5** illustrates a temporal pattern that is employed in at least one embodiment, in addition to the elements of physical geometry and electrical conduction so as to provide an advantageous ACS **100**. For ease of discussion and illustration, in FIG. **5**, first structure **500** is shown having a first plurality of

three-dimensional nanostructures, specifically, four nanostructures **502~508**. Each nanostructure **502~508** has is shown as having a different height "H_F". Second structure **510** is shown having a second plurality of three-dimensional nanostructures, specifically four nanostructures **512~518**. Each nanostructure **512~418** is shown as having substantially the same height "H_S".

As the first and second structures **500**, **510** are brought together, the first instance of proximate contact is between nanostructures **506** and **516**. The second instance of proximate contact is between nanostructures **508** and **518**. The third instance of proximate contact is between nanostructures **502** and **512**. The final instance of proximate contact is between nanostructures **504** and **514**.

The compliant nature of nanostructures **502~508** is demonstrated with slight bulging of nanostructures **502**, **506** and **508**. Although not illustrated, it is of curse understood and appreciated that nanostructures **512~518** may also be compliant.

In at least one embodiment, the temporal pattern in which proximate contact is established is used to establish a specific electrical patter or circuit within ACS **100**. For example, the first instance of proximate contact between nanostructures **508** and **518** may establish a transistor which permits a flow of current that would not occur if nanostructures **508** and **518** were not the first to establish proximate contact.

FIG. **6** further illustrates the hidden nature of at least one embodiment of ACS **100**. Shown is a first structure **600**, a second structure **602** and a human scale alignment device **604**. Second structure **602** and human scale alignment device **604** are joined to the surface of an article of manufacturer **606**. While a user may see, touch, hold and otherwise use first and second structures **600**, **602**, and may even know that they employ first and second pluralities of nanostructures (e.g., **104**, **108** shown in dotted enlarged portions **608** and **610**, respectively), the location of these structures is hidden and unknown to the user.

The hidden nature of the nanostructures may be due simply to their minute size as discussed above, or may additionally be enhanced by placing them below the surface of each structure. In at least one embodiment, a plurality of different locations of nanostructures may be provided; however, only a subset are truly involved in the anti-counterfeiting system.

As illustrated in FIGS. **1~4** an alignment device may be incorporated as part of the first and second structures (e.g., **102 106**). As shown in FIG. **6**, a human scale alignment device may also be employed. Various human scale alignment devices are known that permit micron and submicron alignment. It is also understood and appreciated that in an ACS **100** embodiment relying on capacitive proximity, magnetic and/or photoelectric effect without physical contact between the nanostructures, proper alignment may be necessary for only a brief period of time, thus permitting a user to slide one structure past the other.

One such human scale alignment mechanism is a called a kinematic mount. It consists of three hard metallic spherical surfaces (for example, ball bearings) affixed rigidly to one surface. The mating surface contains v-grooves oriented in different directions that match the spherical surfaces. In the proper position the ball touches both sides of the v-groove. If the first surface is offset with respect to the second, the spherical surface only contacts one side of the v-groove and provides a force to move the relative position of the surfaces to the proper alignment. Such systems are capable of repeatable submicron alignment of the two surfaces. In at least one embodiment, ACS **100** employs a Kinematic mount as the alignment mechanism.

So as to provide authentication and thwart counterfeiting, in at least one embodiment, the first structure **102** is affixed to an article of manufacturer. Such an article may be packaging containing a product, or it may be a product itself such as, but not limited to, an ink or toner cartridge. In at least one embodiment, the first structure **102** provides an adhesive layer on the side opposite from the first plurality of nanostructures **104**. As such, the first structure **102** may be affixed to products, packages, printed materials, or other items.

In at least one embodiment, ACS **100** is provided by processes including Self-Aligned Imprint Lithography ("SAIL"), a recently developed technique for producing multilayer patterns on flexible substrates. The basics of this process are set forth and described in U.S. patent application Ser. No. 10/104,567, entitled "Method and System for Forming a Semiconductor Device" published as U.S. Patent Publication Number 20040002216, the disclosure of which is incorporated herein by reference.

The SAIL technique uses a 3D patterned resist and is typically employed in roll-to-roll processing. As the 3D resist is flexible, the pattern will stretch or distort to the same degree as the substrate. As such, a SAIL roll-to-roll fabrication process may be employed to provide low cost manufacturing solutions for devices such as flat and/or flexible displays, or other devices suitable for roll-to-roll processing.

Utilizing height differences in an imprinted 3D stamp or other provided 3D structure, multi-level pattern information is provided and self-alignment maintained independent of the instability of a flexible substrate. It shall also be realized that the disclosed method may be employed upon a non-flexible substrate while remaining within the spirit and scope of at least one embodiment.

Fabrication of ACS **100** may also involve the process set forth and described in U.S. patent application Ser. No. 11/062,384, entitled "A Method for Forming an Electronic Device", the disclosure of which is incorporated herein by reference. Briefly stated, U.S. patent application Ser. No. 11/062,384 combines imprint lithography with manufacturing patterning techniques of printing, imprinting, embossing, laser scanning, and combinations thereof for fabrication processes which may be performed in a roll-to-roll environment.

It is of course understood and appreciated that such fabrication processes will provide the first plurality of nanostructures **104** and the second plurality of nanostructures **106**, the two pluralities so configured to couple by physical contact, electrical contact, capacitive proximity and/or combinations thereof. Despite the small scale advantageously employed in ACS **100**, the roll-to-roll processes permit fabrication of physically separate components with appropriate tolerances to establish proximate contact. For example, in at least one embodiment, tolerances of about 0.1 to 10 microns are sufficient.

Roll-to-roll technology, also referred to as web fabrication, is a relatively new technology for the large scale production of nano-scale structures. The capital investment and tooling required to establish a roll-to-roll process is significant and generally only available to large scale manufacturers producing a high volume of products. As such, investment in roll-to-roll technology for the simple purpose of fabricating counterfeit versions of the devices herein described is advantageously unlikely. Moreover, even with roll-to-roll technology, without prior knowledge of the electrical conduction elements of the ACS **100**, structural fabrication will not suffice to provide a working counterfeit device.

Having described the above structural embodiments of ACS **100**, an alternative embodiment with respect to an anti-counterfeiting method will now be described with reference

to the flow diagram of FIG. **7**. It will be appreciated that the described events and method of operation need not be performed in the order in which they are herein described, but that this description is merely exemplary of one method of operation in accordance with at least one embodiment.

With respect to FIG. **7**, in at least one embodiment, the anti-counterfeiting method commences by providing a first structure having a first plurality of three-dimensional nanostructures, block **700**. A second structure having a second plurality of three-dimensional nanostructures configured to couple with the first plurality is also provided, block **702**. In at least one embodiment, either the first or second structure is affixed to an article of manufacturer, for example, the first structure may be affixed to a product packaging or the physical product itself.

A user wishing to verify the article of manufacturer as non-counterfeit then aligns the second structure to the first structure, block **704**. This alignment establishes proximate contact between the first and second pluralities of nanostructures, block **706**. An evaluation is then performed to evaluate at least one instance of proximate contact between a first and second nanostructure to verify non-counterfeit status, block **708**. In at least one embodiment, such evaluation includes measuring electrical capacitance and/or confirming electrical contact between the nanostructures.

Assuming that the second structure is affixed to an article of manufacture and the first structure is under the control of a user, the evaluation process determines the validity, or non-counterfeit status of the article of manufacturer, decision **710**. In other words, if the evaluation is positive, the user is informed that the article of manufacture is authentic, **712**. If the evaluation is negative, the user is informed that the article of manufacture is counterfeit, block **714**.

In at least one embodiment, the notification is a simple light, e.g., red or green. In alternative embodiments, more complex and/or complete visual information, auditory information, or electrical enabling of functionality forms of notification may be employed. One variation advantageously different from typical lock and key systems is that one party, such as a merchant, could be informed about the counterfeit nature without alerting the party passing the counterfeit item. This would enable tracing of the counterfeiting to the source without tipping off the counterfeiter.

In an embodiment wherein the first structure is physically on a product (e.g., an ink or toner cartridge), and the evaluation is performed by a controller within the printer, an action is initialized based on the evaluated status. More simply stated, if the evaluation is not confirmed, the printer will not print, as the provided ink or toner is evaluated as counterfeit.

Changes may be made in the above methods, systems and structures without departing from the scope hereof. It should thus be noted that the matter contained in the above description and/or shown in the accompanying drawings should be interpreted as illustrative and not in a limiting sense. The following claims are intended to cover all generic and specific features described herein, as well as all statements of the scope of the present method, system and structure, which, as a matter of language, might be said to fall therebetween.

What is claimed is:

1. An anti-counterfeiting system, comprising:

a first structure having a first plurality of three-dimensional nanostructures each having a height dimension less than a wavelength of visible light;

a second structure having a second plurality of three-dimensional nanostructures each having a height dimension less than a wavelength of visible light, the second plurality configured to couple with the first plurality; and

an alignment mechanism, operable to align the first structure to the second structure and establish proximate contact between the first and second pluralities of three-dimensional nanostructures;

wherein the first plurality of three-dimensional nanostructures encodes a first part of an authentication key, and wherein the second plurality of nanostructures encodes a second part of the authentication key, the authentication key including pre-determined elements and interaction modalities.

2. The anti-counterfeiting system of claim **1**, wherein the first and second pluralities of three-dimensional nanostructures have hidden locations unknown to a user.

3. The anti-counterfeiting system of claim **1**, wherein the first and second pluralities of three-dimensional nanostructures are copy-resistant.

4. The anti-counterfeiting system of claim **1**, wherein the first and second pluralities of three-dimensional nanostructures have a size resolution that prohibits reproduction.

5. The anti-counterfeiting system of claim **1**, wherein the second structure is disposed upon an article of manufacture.

6. An anti-counterfeiting system, comprising:

a first structure having a first plurality of hidden three-dimensional nanostructures;

a second structure having a second plurality of hidden three-dimensional nanostructures, the second plurality configured to couple with the first plurality; and

an alignment mechanism, operable to align the first structure to the second structure and establish proximate contact between the first and second pluralities of hidden three-dimensional nanostructures.

7. The anti-counterfeiting system of claim **6**, wherein the second structure is disposed upon an article of manufacture.

8. The anti-counterfeiting system of claim **6**, wherein the first and second pluralities of hidden three-dimensional nanostructures are copy-resistant.

9. The anti-counterfeiting system of claim **6**, wherein the first and second pluralities of hidden three-dimensional nanostructures have a size resolution that prohibits reproduction.

10. The anti-counterfeiting system of claim **6**, wherein locations of the first and second pluralities of hidden three-dimensional nanostructures are unknown to a user.

11. The anti-counterfeiting system of claim **6**, wherein the configuration to couple is selected from capacitive proximity, electrical contact, physical contact, magnetic interaction, photoelectrical interaction and combinations thereof.

12. The anti-counterfeiting system of claim **6**, wherein the first and second pluralities of hidden three-dimensional nanostructures are formed from compliant materials.

13. The anti-counterfeiting system of claim **12**, wherein the compliant materials deform to provide a temporal pattern as proximate contact between nanostructures of the first and second pluralities of hidden three-dimensional nanostructures occurs.

14. The anti-counterfeiting system of claim **6**, wherein the first plurality of hidden three-dimensional nanostructures encodes a first part of an authentication key, and wherein the second plurality of hidden three-dimensional nanostructures encodes a second part of the authentication key, the authentication key including pre-determined elements and interaction modalities.

15. The anti-counterfeiting system of claim **6**, wherein the second structure is affixed to an article of manufacturer.

16. An anti-counterfeiting system, comprising:

a first structure having a first plurality of copy-resistant three-dimensional nanostructures;

a second structure having a second plurality of copy-resistant three-dimensional nanostructures, the second plurality configured to couple with the first plurality; and

an alignment mechanism, operable to align the first structure to the second structure and establish proximate contact between the first and second pluralities of copy-resistant three-dimensional nanostructures.

17. The anti-counterfeiting system of claim **16**, wherein the first and second pluralities of copy-resistant three-dimensional nanostructures have a size resolution that prohibits reproduction.

18. The anti-counterfeiting system of claim **16**, wherein the first and second pluralities of copy-resistant three-dimensional nanostructures have hidden locations unknown to a user.

19. The anti-counterfeiting system of claim **16**, wherein the configuration to couple is selected from capacitive proximity, electrical contact, physical contact, magnetic interaction, photoelectrical interaction and combinations thereof.

20. The anti-counterfeiting system of claim **16**, wherein the first and second pluralities of copy-resistant three-dimensional nanostructures are formed from compliant materials.

21. The anti-counterfeiting system of claim **20**, wherein the compliant materials provide a temporal pattern as proximate contact between copy-resistant three-dimensional nanostructures of the first and second pluralities of nanostructures occurs.

22. The anti-counterfeiting system of claim **16**, wherein the first plurality of copy-resistant three-dimensional nanostructures encodes a first part of an authentication key, and wherein the second plurality of copy-resistant three-dimensional nanostructures encodes a second part of the authentication key, the authentication key including pre-determined elements and interaction modalities.

23. The anti-counterfeiting system of claim **16**, wherein the second structure is affixed to an article of manufacturer.

24. An anti-counterfeiting system, comprising:

a first structure having a first plurality of hidden, copy-resistant three-dimensional nanostructures;

a second structure having a second plurality of hidden, copy-resistant three-dimensional nanostructures, the second plurality configured to couple with the first plurality; the second structure disposed upon an article of manufacturer; and

an alignment mechanism, operable to align the first structure to the second structure and establish proximate contact between the first and second pluralities of hidden, copy-resistant three-dimensional nanostructures.

25. The anti-counterfeiting system of claim **24**, wherein the article of manufacturer is selected from a package, a case, an ink cartridge, a toner cartridge, a food product, or combinations thereof.

26. The anti-counterfeiting system of claim **24**, wherein the resolution of the first and second pluralities of hidden, copy-resistant three-dimensional nanostructures prohibits reproduction.

27. The anti-counterfeiting system of claim **24**, wherein each nanostructure of the first and second pluralities of hidden, copy-resistant three-dimensional nanostructures has a height less than a wavelength of visible light.

28. The anti-counterfeiting system of claim **24**, wherein locations of the first and second pluralities of hidden, copy-resistant three-dimensional nanostructures are unknown to a user.

29. The anti-counterfeiting system of claim **24**, wherein the configuration to couple is selected from capacitive proximity, electrical contact, physical contact, magnetic interaction, photoelectrical interaction and combinations thereof.

30. An anti-counterfeiting method, comprising:

providing a first structure having a first plurality of three-dimensional nanostructures;

providing a second structure having a second plurality of three-dimensional nanostructures, the second plurality configured to couple with the first plurality;

aligning the first structure to the second structure, the alignment providing proximate contact between the first and second pluralities of three-dimensional nanostructures; and

evaluating at least one instance of proximate contact between a first and second nanostructure to verify non-counterfeits status.

31. The anti-counterfeiting method of claim **30**, wherein the first and second pluralities of three-dimensional nanostructures are copy-resistant.

32. The anti-counterfeiting method of claim **30**, wherein the first and second pluralities of three-dimensional nanostructures are hidden.

33. The anti-counterfeiting method of claim **30**, wherein the first and second pluralities of three-dimensional nanostructures have a size resolution that prohibits reproduction.

34. The anti-counterfeiting method of claim **30**, wherein aligning the second structure to the first structure provides unique geometric shapes and gaps as the first and second pluralities of three-dimensional nanostructures couple, the shapes and gaps establishing pathways with predetermined magnetic, photoelectric, conductive, capacitance values and/or combinations thereof.

35. The anti-counterfeiting method of claim **30**, wherein at least one nanostructure is formed from a compliant material.

36. The anti-counterfeiting method of claim **35**, wherein the compliant material permits a temporal pattern of proximate contact as the second structure is aligned to the first structure.

37. The anti-counterfeiting method of claim **30**, wherein evaluating at least one instance of proximate contact between a first and second nanostructure includes measuring electrical capacitance.

38. The anti-counterfeiting method of claim **30**, wherein evaluating at least one instance of proximate contact between a first and second nanostructure includes confirming electrical contact.

39. The anti-counterfeiting method of claim **30**, wherein the first plurality of three-dimensional nanostructures encodes a first part of an authentication key, and wherein the second plurality of three-dimensional nanostructures encodes a second part of the authentication key, the authentication key including pre-determined elements and interaction modalities.

40. The anti-counterfeiting method of claim **30**, further including initializing an action based on evaluated status.

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